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HYDRO ELECTRIC POWER INVESTIGATIONS

INVESTIGATION

of

HYDRO ELECTRIC POWER POSSIBILITIES

on

THE FOND-DU-LAC RIVER

for

ELDORADO MINING AND REFINING LTD.

at

BEAVERLODGE LAKE, SASKATCHEWAN

BY

APPENDICES

MONTREAL ENGINEERING COMPANY, LIMITED
CONSULTING ENGINEERS
244 ST. JAMES STREET WEST
MONTREAL
QUEBEC

May 28, 1953

C O N T E N T S

HYDRO ELECTRIC POWER INVESTIGATIONS

A P P E N D I C E S

FOND-DU-LAC RIVER

HYDRO-ELECTRIC POWER INVESTIGATIONS

1. SCOPE OF REPORT

During the spring of 1953 it became apparent that the demand for electric power in the Beaverlodge Lake district of Northern Saskatchewan in the near future might exceed the potential of the Tazin River. Accordingly Montreal Engineering Company Limited, at the request of Eldorado Mining and Refining Ltd., made a study of the rapids on the Slave River between Fort Fitzgerald and Fort Smith and a study of the Fond-du-Lac River between Black Lake and Lake Athabaska.

The Smith Rapids study is the subject of a separate report.

For the Fond-du-Lac study a reconnaissance party consisting of J.K. Sexton, J.A. Randle and J.K.C. Mulherin went to Stony Rapids on March 28th, 1953 where they made headquarters and remained until April 1. They had at their disposal a Norseman aircraft, and were able to study the power sites from the air. Inspection of the river was also made by walking along the shore although this was somewhat hampered by the fact that there was about one and one half feet of snow necessitating the use of snowshoes. The snow did not prevent the determination of characteristics of the ground surface materials. Moreover, the reaches of the river under study were free of ice and it was possible to make close visual inspection of damsites. The aircraft was able to land only on Black Lake and on the airstrip at Stony Rapids, and dog teams were used for transport to and from work.

2. LOCATION

The Fond-du-Lac River rises in Wollaston Lake, situated on the height of land between the Arctic and Hudson's Bay watersheds, and flows generally westward into Black Lake. Its principal tributaries are the Porcupine and Chip-

man Rivers from the north and Cree River from the south, all of which are located above the outlet of Black Lake.

Between Black Lake and Lake Athabaska the Fond-du-Lac River drops 226 feet in three rapid sections thereby creating the power reach of the river which is the subject of study in this report. These rapid sections are separated from each other by a series of lakes as listed below.

Lake	Elevation - feet above sea level	Rapid	Fall	Length
Black Lake	925'			
		Elizabeth Falls	115'	3 miles
Middle Lake	810'			
		Woodcock Rapids	85'	2½ miles
Stoney Lake	725'			
		Stony Rapids	26'	1 mile
Lake Athabaska	699'			

The characteristics of this section of the Fond-du-Lac River are further illustrated by Drawing No. Eldo-6506 which accompanies this report. Elevations for the lakes were obtained from sheet 74-P of the National Topographic Series, scale 4 miles to the inch.

3. WATER SUPPLY

Water from Wollaston Lake is divided between the Fond-du-Lac River and the Cochrane River, which flows eventually into Hudson's Bay. The only measurements of the division of water between the two rivers are as follows:

Date	Wollaston Lake Elevation	Fond-du-Lac River discharge	Cochrane River discharge
Aug. 30-31/1949	94.48	2430 c.f.s.	4950 c.f.s.
Sept. 21-22/1950	93.14	418 c.f.s.	6730 c.f.s.

Date	Wollaston Lake Elevation	Fond-du-Lac River discharge	Cochrane River discharge
June 26-29/1952	91.86	102 c.f.s.	3950 c.f.s.
Mar. 25-26/1953	93.81	30 c.f.s.	2160 c.f.s.

It is not known whether there has been any interference with the natural division of water between the two watersheds, but there is an unexplained inconsistency in the lake level and stream flow readings of March 1953, which should be noted.

The Fond-du-Lac River has a drainage area above the outlet of Black Lake, but exclusive of the Wollaston Lake Drainage Area, of approximately 19,700 square miles. The Wollaston Lake drainage area is approximately 8,400 square miles.

Daily records of the stream flow have been kept at Stony Rapids from September 1, 1946 to date. A tabulation of the average monthly flows is given below:

Average Monthly Flows - c.f.s.

	1946	1947	1948	1949	1950	1951	1952
Jan.		6,820	12,960	9,790	9,300	8,160	5,190
Feb.		6,610	11,880	8,280	7,640	6,740	5,020
Mar.		6,510	9,800	7,720	7,010	6,320	6,080
Apr.		6,470	9,140	7,530	7,030	8,860	7,310
May		10,160	12,170	11,630	11,910	12,470	9,810
June		16,280	15,100	18,350	17,030	15,930	9,730
July		14,900	15,180	18,950	14,890	12,610	8,360
Aug.		12,520	12,250	17,540	13,030	11,390	7,860
Sept.	8,410	13,070	12,770	15,540	11,400	10,380	8,200
Oct.	7,630	16,070	15,560	14,390	10,670	8,810	

Average Monthly Flows - c.f.s. (cont'd.)

	1946	1947	1948	1949	1950	1951	1952
Nov.	7,450	18,160	15,720	13,630	10,450	7,270	
Dec.	7,010	14,100	12,740	12,070	9,380	6,130	

recorded maximum daily flow = 19,690 c.f.s.
recorded minimum daily flow = 4,820 c.f.s.

This flow could be regulated by the creation of storage on Black Lake which has a surface area of about 170 square miles and offers excellent storage possibilities. Low ground is evident at the Western extremity, but inspection from the air indicated that it would probably be feasible to raise the lake by 25 feet if desired.

On the basis of 1951-52, the driest year to date, a dependable regulated flow of 7500 c.f.s. could be obtained by providing approximately 6.5 feet of storage on Black Lake. This figure allows for evaporation losses equal to two feet of storage. It would be possible to obtain a somewhat higher regulated flow by creating a larger amount of storage on Black Lake thus providing carry-over storage for a cycle of dry years.

In any plan to raise the lake, consideration will have to be given to the property of Nisto Mines Ltd. presently doing development work on the north shore, about six miles east of the lake outfall.

Flood discharge capacity of at least 40,000 c.f.s. should be provided for any hydro-electric works constructed below Black Lake.

4. GEOLOGY AND TOPOGRAPHY

Along most of its course from Black Lake to Lake Athabaska, the Fond-du-Lac River follows the contact between the sedimentary rocks of the late Precambrian on the south and the igneous rocks of the early Precambrian on the North. The former are hard sandstones with near horizontal stratification, and the latter consist principally of biotite and gneiss. Only along the downstream

section of the Woodcock Rapids do the gneisses cross to the left hand site of the river where they outcrop along a narrow band terminating a Stony Lake. At Stony Rapids, on the other hand, the sedimentary rocks are present on both sides of the river.

Most of the sedimentary area to the south of the river is covered with glacial drift and is of low relief with extensive muskegs and small hills. From the air these hills appear to be drumlins or eskers running generally east and west. It is on this side of the river that concrete and earth fill materials will probably be found.

On the north side of the river there is little overburden covering the rock. The country is more rugged and is characterized by numerous lakes with steep, rocky hills and valleys.

5. POSSIBLE DEVELOPMENTS

The field examination indicated the Elizabeth Falls and Woodcock Rapids offer attractive prospects for hydro-electric development but that Stony Rapids are not suitable for development at this time. The drop of 26 feet available at the latter is distributed over a one mile length of river and the streambed is relatively wide along this entire length. There is, moreover, some low-lying ground to the north which would probably have to be dammed if Stony Lake was raised.

On the other hand, the Elizabeth Falls and the Woodcock Rapids are in relatively narrow valleys, with much rock outcropping along both banks, and a number of concentrated falls offering attractive damsites. It appears feasible to develop almost all of the head between Black Lake and Stony Lake, and the preliminary study of the terrain indicated that probably three plants would be required, two on Elizabeth Falls to develop the head between Black and Middle Lakes, and one near the lower end of Woodcock Rapids to develop most of the

head between Middle and Stony Lakes. A more detailed topographic survey would be required, however, to confirm the arrangement of plants.

These three plants should be capable of producing about 120,000 continuous electrical HP at site, or about 110,000 electrical HP at Beaverlodge. This latter figure corresponds to 720,000,000 KWHrs/year. Recommended installed capacity at an assumed load factor of 66% would be approximately 214,000 turbine HP divided between the three plants.

Upper Elizabeth Falls Plant

Preliminary investigation of the river suggests that a plant could be located near section 4 of Drawing No. Eldo-6506 to create storage on Black Lake, and develop a head of approximately 50 feet. Development of this head would probably necessitate raising of Black Lake to a higher level than required for storage purposes but this should present no serious difficulties provided that no expensive flooding damages are caused. This aspect of the project would require further investigation. The river at this site is of moderate width with rock apparently outcropping continuously across the section, and a concrete dam incorporating spillways and the powerhouse could be constructed without any great difficulty.

If the estimated 50 feet of head is realized, the ultimate capacity of this site would be approximately 54,000 turbine HP installed as three units of equal size, at least one of which should be of Kaplan type. Possible delivery to Beaverlodge would be approximately 190,000,000 KWHrs. per year.

Pending confirmation from more detailed field surveys, it is recommended that this plant be considered as the first of the three to be constructed. The topography of the site appears most favourable, and this plant, moreover, includes the storage on Black Lake necessary for regulation of the river.

It should be possible to complete the initial installation in about two and one half years from the start of construction, provided no trouble was encountered in delivery of the equipment.

Lower Elizabeth Falls Plant

This plant should utilize as much of the available head between the tailwater of the upper plant and Middle Lake as is economically feasible. A dam can be located in the reach between sections 9 and 10 on drawing Mldo-6506 for this purpose. Section 9 appears to be a better dam site with a narrower section than could be had further downstream but there is a drop of 30' ± from section 9 to Middle Lake so that conduits would probably be necessary to conduct the water to a powerhouse near section 10. Some tailrace excavation would appear to be feasible below section 10. A head of approximately 75' is believed available at this site and installed capacity would be approximately 80,000 turbine HP. Rock outcrops along both banks throughout this reach, and construction would not appear to be too difficult, although the rock on the left bank is badly shattered on the surface, and considerable amounts of foundation excavation might be required.

Woodcock Rapids

The drop between Middle Lake and Stony Lake is mainly concentrated in two falls of about 25' and 35' respectively. It is expected that a dam about 50 feet high could be built above the lower fall to raise the water level to the tailwater of lower Elizabeth Falls Plant, although it would be first necessary to check the topography at the West end of Middle Lake to make sure that water did not spill over towards Stony Lake. A head of about 75 feet is believed to be available, and the installed capacity would be approximately 80,000 turbine HP. Igneous rock outcrops on both sides of the river and on

several islands in the river above the falls, and construction at this site should present no unusual difficulties.

Alternatively, it might be desirable to divide the head in this section of the river between two sites; one located at each of the two principal falls. Conditions at both sites are good, with sound foundation rock throughout. Very low dams would be sufficient, and it is possible that overflow weirs might be used.

The river is apparently open during most of the winter and frazil ice may be prevalent during cold weather. This will not cause any trouble when the river is fully developed from Black Lake to Stony Lake. Nor would it cause trouble at an initial development at the Upper Elizabeth Falls site or at the full Woodcock Rapids development. It might, however, obstruct winter flow at an initial low dam project on Lower Woodcock, or even at the Lower Elizabeth Falls site.

6. TRANSPORTATION, AVAILABILITY OF MATERIALS

Transportation facilities to the Fond-du-Lac power sites are similar to those for the Beaverlodge area. Stony Rapids is served by boats operating on Lake Athabaska from Waterways, and all of the heavy equipment could be brought in this way. A trail has been cut through the woods from Stony Rapids to the head of Elizabeth Falls and with some grading and surfacing this could be made into an all weather road. Branches from this to each of the three sites would be over relatively easy ground. There is also an airstrip at Stony Rapids which would likely be serviceable throughout the year, except for short periods in the spring.

The entire area is quite thickly wooded, but no large stands of timber suitable for sawlogs were observed. However, there is abundant small timber for cofferdam construction.

Concrete aggregates were not examined during the reconnaissance but are believed to be available in the glacial deposits on the south side of the river, within moderate hauling distance of the dam sites.

Earth fill materials, which might be required for low dykes at the ends of one or more of the dams, would also appear to be available on the south side of the river.

7. TRANSMISSION LINE

A transmission line from Elizabeth Falls to Beaverlodge would be about 120 miles long, with the greater part of this length lying along the north side of Lake Athabaska in rugged, rocky terrain. Construction of the line would be somewhat simplified by the fact that it could be serviced at almost any point throughout its length by boats operating on Lake Athabaska. Cost of a line capable of transmitting the initial requirements of power would be of the order of $23,000 per mile.

8. COSTS

Until accurate surveys are made there is insufficient information on which to base a reliable estimate, but by comparing with other projects of the same general magnitude it is believed that an initial installation of two 18,000 HP units at Upper Elizabeth Falls capable of delivering 120,000,000 KWHrs per year to Beaverlodge would cost some $12,000,000. including one transmission line. The addition of the third 18,000 HP unit and the second transmission line would cost approximately $5,000,000. and would increase the energy delivered to Beaverlodge to 180,000,000 KWHrs per year. In a separate report it is shown that a comparable amount of energy from the Slave River would cost approximately twice as much.

The tabulation below gives the approximate comparison between Fond-du-Lac, Charlot River and Camsell Portage developments.

Development	Installed Horsepower	Electrical Horsepower delivered to Beaverlodge	Electrical Energy delivered to Beaverlodge KWHrs/year	Estimated Cost Total	Estimated Cost Per Horsepower at Beaverlodge
Waterloo Lake Plant plus Wellington Lake Plant with second unit added.	12,600	11,100	47,000,000	35,188,000	$467.
Lower Camsell Portage and Upper Camsell Portage Plants with pumping station at Tazin Lake	36,000	30,000	98,000,000 (1)	10,757,000	$358.
Lower Camsell Portage and Upper Camsell Portage with dam to raise Tazin Lake to elev. 1177.0 (1130 (47' RAISE) thus eliminating pumping (2)	36,000	30,000	122,000,000	12,193,000	$406.
36000 hp initial development at Upper Elizabeth Falls plus one transmission line	36,000	30,000	120,000,000	12,000,000	$400.
54000 hp ultimate development at Upper Elizabeth Falls plus two transmission lines	54,000	45,000	180,000,000	17,000,000	$378.

(1) 24,000,000 KWHrs. per year allowed for pumping

(2) Raising Tazin Lake means the provision of 3,700,00 acre feet of dead storage. Present knowledge of water supply indicates that this would be possible only after an indefinite number of years.

9. CONCLUSIONS

The development of power on the Fond-du-Lac River below Black Lake is entirely feasible and would constitute a reliable power supply for the Beaverlodge area and such other mining centers as may be developed in the far north of Saskatchewan. To justify a project of this magnitude, however, the

foreseeable demand for electric energy at Beaverlodge should be 120,000,000 KWHrs per year or more. Lesser demands could be met more economically by development of power on the Charlot River or at Camsell Portage.

If it is believed that the demand for energy may justify development at Fond-du-Lac, then the following steps should be taken as preliminary to construction.

1. Aerial photography of Elizabeth Falls and Woodcock Rapids, and preparation of contour map of Elizabeth Falls area. Probable cost of air survey contractor = $4993. (See bid of Photographic Surveys (Quebec) Limited in Appendix A)

2. Despatch of a ground survey party to Elizabeth Falls to establish ground control for aerial survey, investigate consequences of raising Black Lake, investigate construction material supply, investigate foundation conditions and make detailed measurements of damsite selected from aerial contour map. Estimated cost inclusive of head office expenses = $30,000.

3. Approach the Saskatchewan Government to determine their views on the raising of the level of Black Lake. If approval is obtained then a request should be made for prohibition of further claims staking for 30' above existing lake level until the final water elevation is determined.

NOTE: If close field investigation disclosed unexpected physical difficulties in development of the upper site at Elizabeth Falls, or if the Saskatchewan Government refused permission to raise Black Lake it might then become necessary to transfer the ground survey party to Woodcock Rapids and prepare an aerial contour map of this section of the river also.

JKG/JAR/wp
May 28, 1953

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APPENDIX "A"

SUMMARY OF QUOTATIONS FOR AERIAL PHOTOGRAPHY AND MAPPING

Item		Photographic Surveys (Quebec) Limited	Spartan Air Surveys Ltd.
1.	Photography & mapping of Area A*	$4,393.00	$4,576.00
2.	Photography of Area B*	2,700.00	2,300,00
3.	Photography & mapping of Area A Photography of Area B	4,993.00	Not quoted
4.	Photography & mapping of Black Lake	Based on land area = 250,000 Ac. $20,450.00	Based on land area = 160,000 Ac. $25,000.00
5.	Photography & mapping of Area A Photography of Area B Photography & mapping of Black Lake	$23,168.00	$27,793.00
6.	Photography & mapping of Area A Photography of Area B Photography of Black Lake	$6,918.00	$10,093.00
7.	Completion of Photography	End of May with immediate start	End of May with immediate start
8.	Delivery of Area A maps	One month after receipt of ground control	Thirty days after receipt of ground control
9.	Delivery of Black Lake Maps	4 months after receipt of ground control	3 months after receipt of ground control
10.	Ground control required for Map of Area A	horizontal 4 or more identities along stadia traverse over portage route vertical 4 identities along portage route and 4 along river course	horizontal 3 or more identities along stadia traverse near river veritcal 12 identities on two level traverses
11.	Ground control required for map of Black Lake	horizontal identification of existing points vertical levels on surrounding lakes (≐40 miles of level traverse)	horizontal 25 identities located by stadia vertical 200 identities around lake (≐150 miles of level traverse)

* Area A - Strip along Elizabeth Falls
Area B - Woodcock Rapids and Middle Lake

APPENDIX "B"

ESTIMATED COST OF PRELIMINARY ENGINEERING

This estimate covers the following items of work:

(i) Ground control surveys for Elizabeth Falls Mapping

6 man survey party for 1 month.

(ii) Investigation of consequences of raising Black Lake

6 man survey party for 3 weeks

(iii) Investigation of Construction Materials Supply

4 test-pitters for 1 month.

(iv) Investigation of Damsite Foundations

Diamond Drill crew.

(v) Accurate measurements at chosen damsite

6 man survey party for 1 week.

Also included is a party chief to supervise and co-ordinate the work.

Fares - Montreal to Edmonton, return	3 x 265	$ 795.
Expenses, excess baggage, etc.	3 x 100	300.
Fares - Edmonton to Beaverlodge	9 x 50	450.
Engineers' salaries (incl. overhead)	3 x 2 x 800	4,800.
Rodmen's salaries	4 x 2 x 225	1,800.
Salaries, Cook & bullcook	2 x 375	750.
Transportation, erecting and striking camps, servicing, etc.	Allow	750.
Lumber for Camps	Allow	500.
Camp Expenses	9 x 60 x 5.00/man day	2,700
Aircraft	50 hours @ $70./hour	3,500
Test pitting program	100 man days @ $10.	1,000
		$17,345.

	Carried Forward	$17,345.
tingencies Allow 15%		2,600.
		19,945.
ndation investigation Allow		6,000.
		$25,945.
ice staff to prepare preliminary plans and nstruction estimates		4,000.
		$29,945.
	Say	$30,000.

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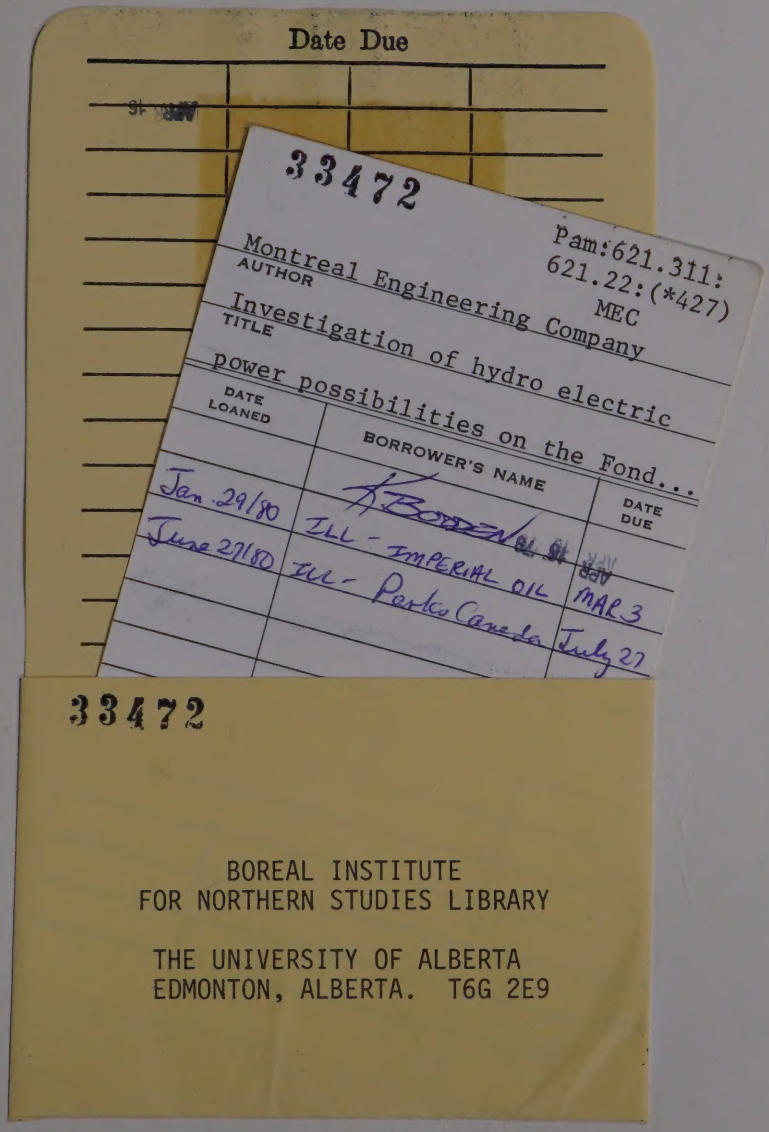
/wp
28, 1953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